

# Quick Drought Response Index (QuickDRI)

## *A Composite Index for Monitoring Rapid-Onset Agricultural Drought*

Tsegaye Tadesse<sup>1</sup>, Brian Wardlow<sup>1,2</sup>, Mark Svoboda<sup>1</sup>, Jesslyn Brown<sup>3</sup>,  
Martha Anderson<sup>4</sup>, Chris Hain<sup>5</sup>, Matt Rodell<sup>6</sup>, and David Mocko<sup>6</sup>

<sup>1</sup>National Drought Mitigation Center (NDMC), University of Nebraska-Lincoln

<sup>2</sup>Center for Advanced Land Management Information Technologies (CALMIT), University of Nebraska-Lincoln

<sup>3</sup>USGS Center for Earth Resources Observation Science (EROS)

<sup>4</sup>USDA Agricultural Research Service (ARS)

<sup>5</sup>Earth System Science Interdisciplinary Center, University of Maryland

<sup>6</sup>NASA Goddard Space Flight Center (GSFC)

**NASA Applied Sciences Program: Water Resources Meeting**

**NOAA National Weather Center**

**205 Hackberry Ln, Tuscaloosa, AL 3540**

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# Quick Drought Response Index (QuickDRI)

**QuickDRI** is a ‘hybrid’ drought index that monitors rapid, short-term changes in agricultural drought conditions through the integration of:

- satellite-based observations of vegetation conditions
- evapotranspiration (ET) estimates from satellite
- root-zone soil moisture (satellite-estimated or modeled)
- climate-based drought index data
- biophysical characteristics of the environment.

***Goal:*** Use recently available remote sensing products that are shorter-term indicators of drought-related environmental conditions to develop complimentary, operational tool over the CONUS to VegDRI that **characterizes shorter-term, rapid-onset agricultural drought conditions on the order of weeks to a month.**

# Targeted Applications for QuickDRI

## U.S. Drought Monitor (USDM)

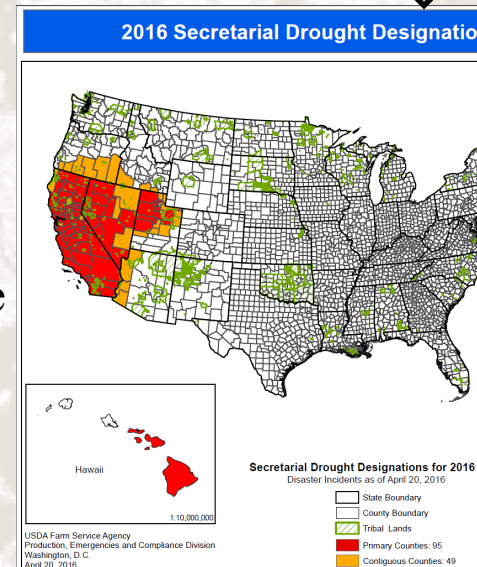
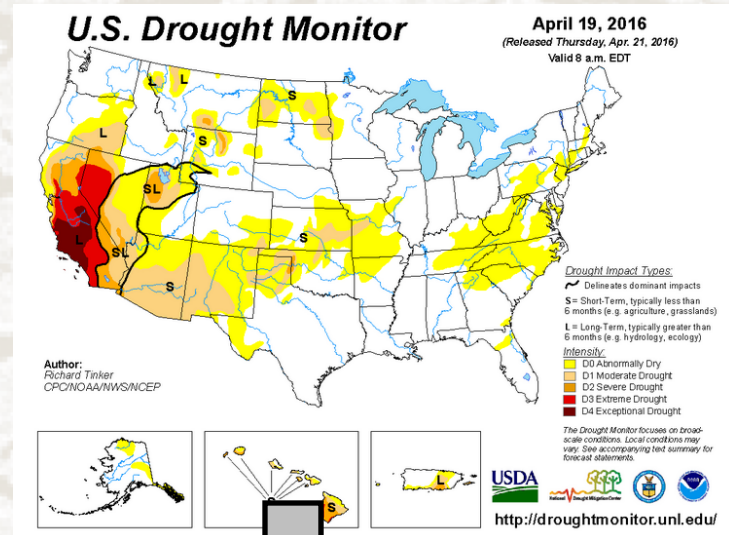
Current state-of-the-art drought monitoring tool for the U.S. that is used in federal and state programs and by the media to communicate drought conditions.

Composite index that incorporates various types of data through expert analysis by drought experts.

**Challenge:** Increasing demand to use the USDM for county- to subcounty-level decisions requiring higher spatial resolution information to characterize more spatially-detailed drought patterns.

## USDA Livestock Forage Disaster Program (LFP)

The 2008 and 2014 Farm Bills mandated the USDA Farm Service Agency (FSA) RFP use the USDM as the primary trigger to establish county-level eligibility for financial assistance to cover drought-related grazing losses.



### Eligible Counties for Drought

An eligible livestock producer that owns or leases grazing land or pastureland physically located in a county rated by the U.S. Drought Monitor <http://droughtmonitor.unl.edu/> as having a:

- D2 (severe drought) in a county for eight consecutive weeks or more during the normal grazing period: assistance equals **one monthly payment**;
- D3 (extreme drought) in a county anytime during the normal grazing period: assistance equals **three monthly payments**;
- D3 (extreme drought) in a county for four weeks or more during the normal grazing period or D4 (exceptional drought) anytime during the normal grazing period: assistance equals **four monthly payments**;
- D4 (exceptional drought) in a county for four weeks (consecutive weeks unnecessary) during the normal grazing period: assistance equals **five monthly payments**.

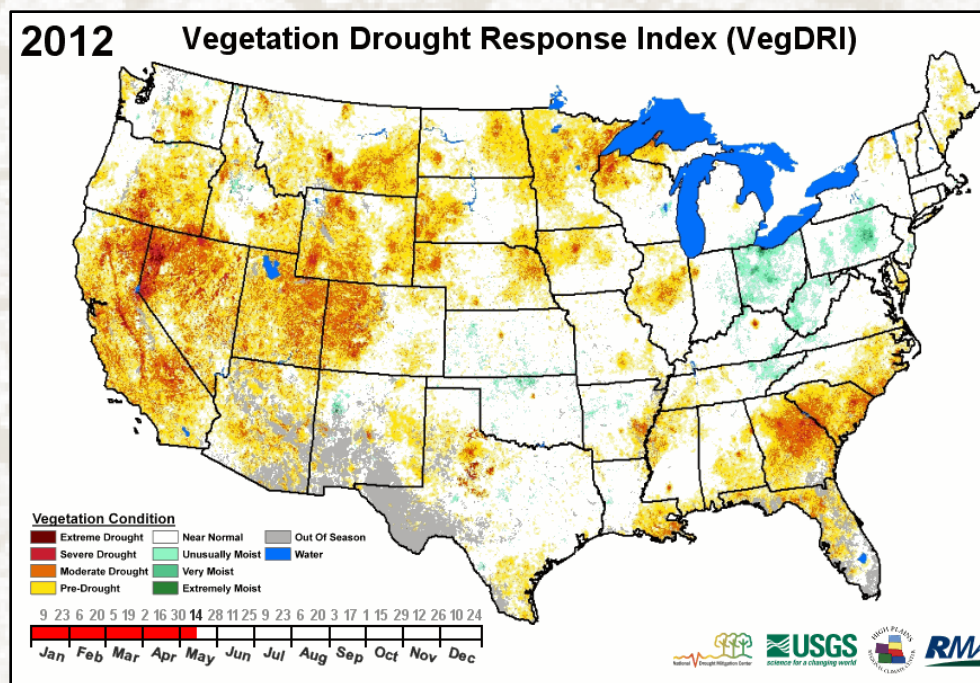
# Vegetation Drought Response Index (VegDRI)

VegDRI is a ‘composite’ drought index that integrates:

- satellite-based observations of vegetation conditions
- climate-based drought index data
- biophysical characteristics of the environment

to produce 1-km spatial resolution maps that depict ‘*drought-related*’ *vegetation stress*.

Operational agricultural drought monitoring tool over the CONUS since 2008. Proven to be a useful indicator of ‘seasonal’ agricultural drought conditions, but has limited ability to characterize rapid, short-term changes in conditions.

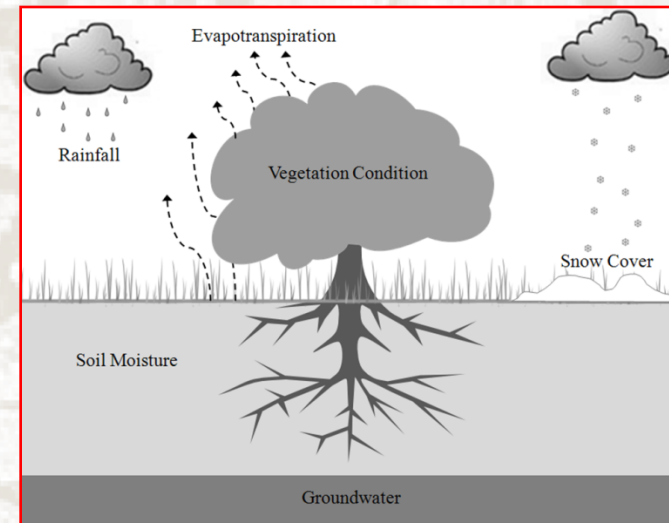


# Emerging Satellite-based Drought Monitoring Tools

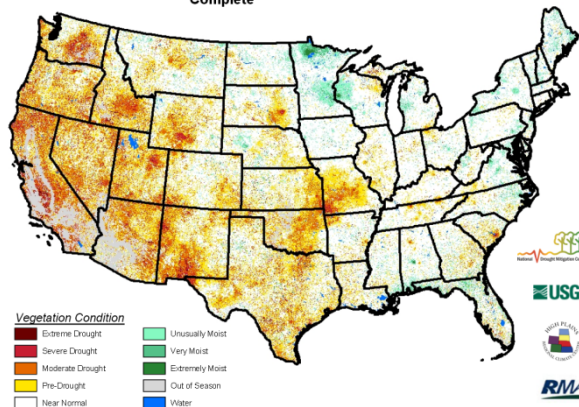
Over the past 10+ years, there has been a rapid development of remote sensing-based drought monitoring tools characterizing different parts of the hydrologic cycle that influence drought conditions.

## Examples

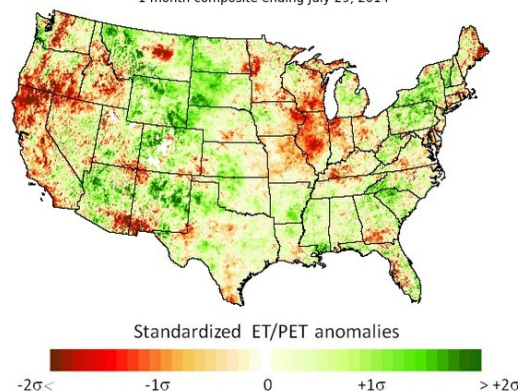
- Evaporative Stress Index (ESI)
- GRACE Terrestrial Water Storage (TWS) anomalies
- Vegetation Drought Response Index (VegDRI)



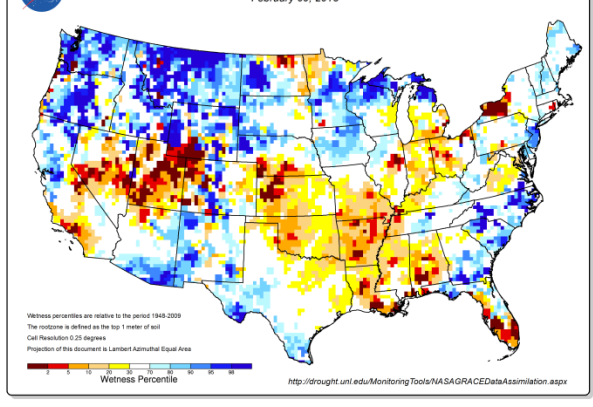
**Vegetation Drought Response Index**  
Complete  
July 28, 2014



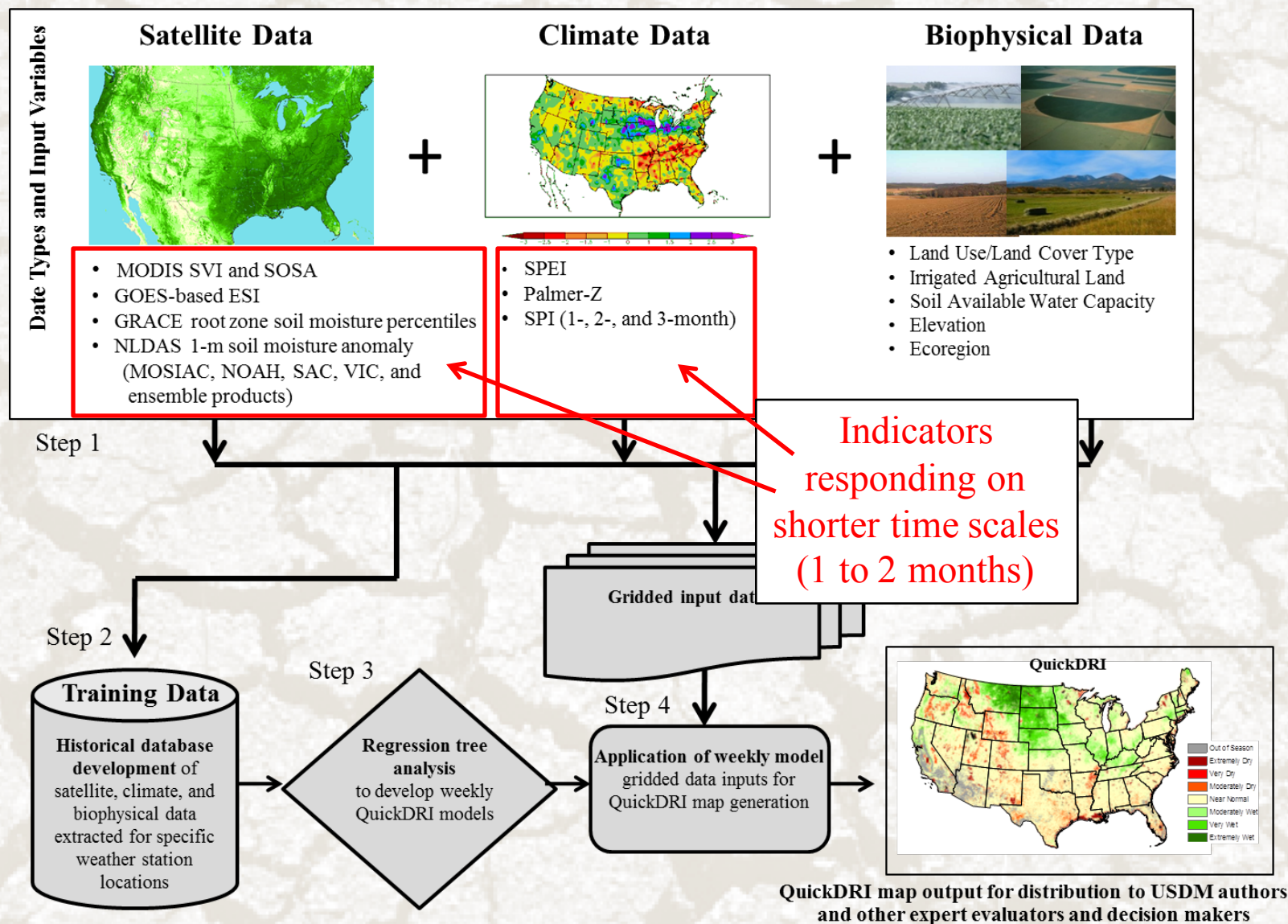
**Evaporative Stress Index 4km**  
1 month composite ending July 29, 2014



**GRACE-Based Root Zone Soil Moisture Drought Indicator**  
February 09, 2015



# QuickDRI Methodology



# Milestones - QuickDRI Training Database Development

## QuickDRI Input Datasets for Testing

SVI *
Zscore
SOSA
ESI Anomaly 2-wk
ESI Anomaly 4-wk *
ESI Anomaly 8-wk
ESI Anomaly 12-wk
GRACE Root Zone Soil Moisture Percentile
NLDAS Ensemble Mean 1-m Soil Moisture Percentile Monthly
NLDAS Ensemble Mean 1-m Soil Moisture Anomaly Monthly
NLDAS Ensemble Mean 1-m Soil Moisture Percentile Weekly
NLDAS Ensemble Mean 1-m Soil Moisture Anomaly Weekly
NLDAS-2 SAC 1-m Soil Moisture Percentile Monthly
NLDAS-2 SAC 1-m Soil Moisture Anomaly Monthly
NLDAS-2 SAC 1-m Soil Moisture Percentile Weekly
NLDAS-2 SAC 1-m Soil Moisture Anomaly Weekly
NLDAS VIC 1-m Soil Moisture Percentile Monthly
NLDAS VIC 1-m Soil Moisture Anomaly Monthly
NLDAS VIC 1-m Soil Moisture Percentile Weekly *
NLDAS VIC 1-m Soil Moisture Anomaly Weekly
NLDAS NOAH 1-m Soil Moisture Percentile Monthly
NLDAS NOAH 1-m Soil Moisture Anomaly Monthly
NLDAS NOAH 1-m Soil Moisture Percentile Weekly
NLDAS NOAH 1-m Soil Moisture Anomaly Weekly
NLDAS Mosaic 1-m Soil Moisture Percentile Monthly
NLDAS Mosaic 1-m Soil Moisture Anomaly Monthly
NLDAS Mosaic 1-m Soil Moisture Percentile Weekly
NLDAS Mosaic 1-m Soil Moisture Anomaly Weekly

Vegetation  
Index

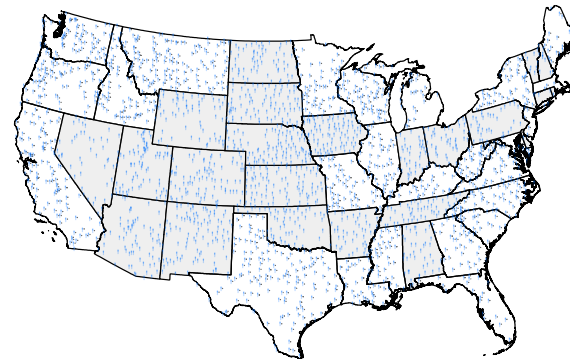
ET

Soil  
Moisture

Precip.

Biophysical

SPEI 1-month *
SPEI 2-month
SPEI 3-month
SPI weekly 1-6
SC-PDSI
Landcover *
Soil Available Moisture Capacity *
Elevation *
Irrigated Agricultural Land *
Ecoregions *



Locations of the 2,427 weather stations used to extract the training data for the QuickDRI models.

- QuickDRI models developed from analysis of **14-year time-series data** of ‘dynamic’ variables over CONUS for period of 2000 to 2014.
- Biophysical variables ‘static’ over the entire history.

**\* Selected inputs for the final, operational QuickDRI models.**

# Milestones – Operational QuickDRI Model Selection

Developed 52 weekly QuickDRI models spanning the calendar year to be implemented over the continental U.S. within the operational QuickDRI system hosted at the USGS EROS.

**An example of a weekly, regression tree-based QuickDRI model.**

## Data Inputs

### **Dependent variable**

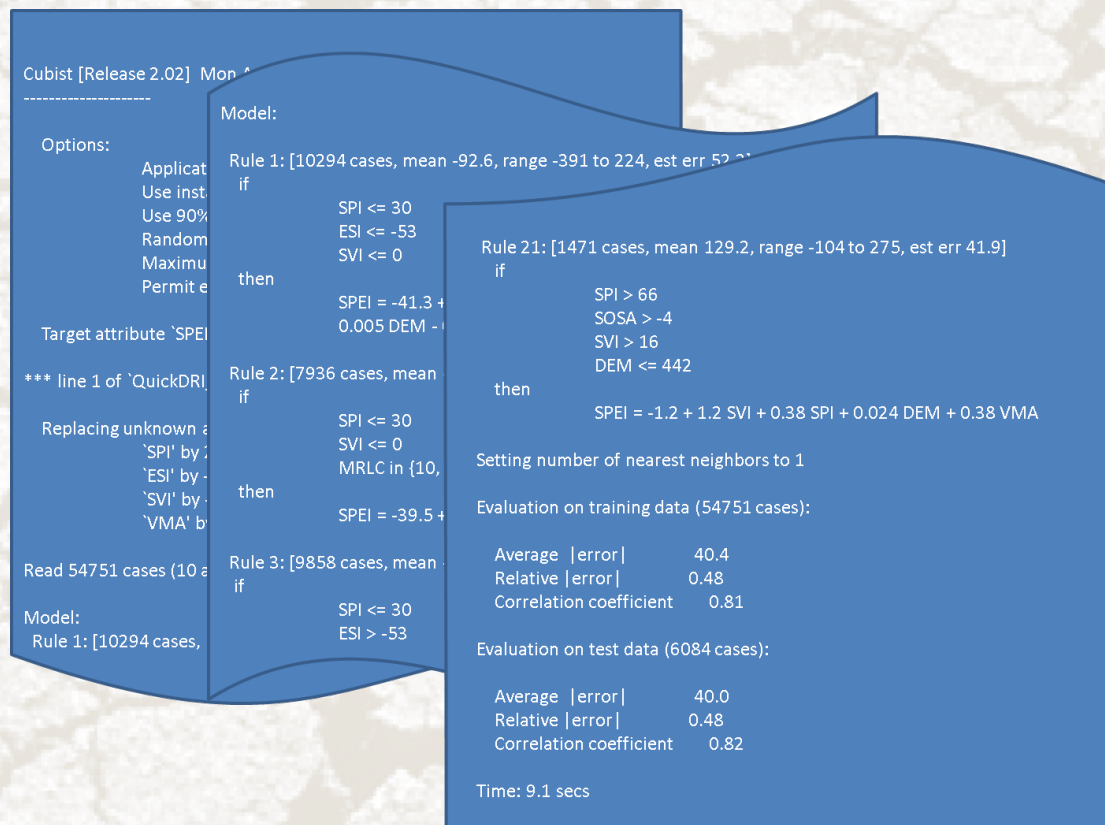
- SPEI (1 month)

### **Independent variables:**

- SPI (1 month)
- ESI anomaly (4 week)
- SVI
- VIC soil moisture
- Start of Season Anomaly (SOSA)

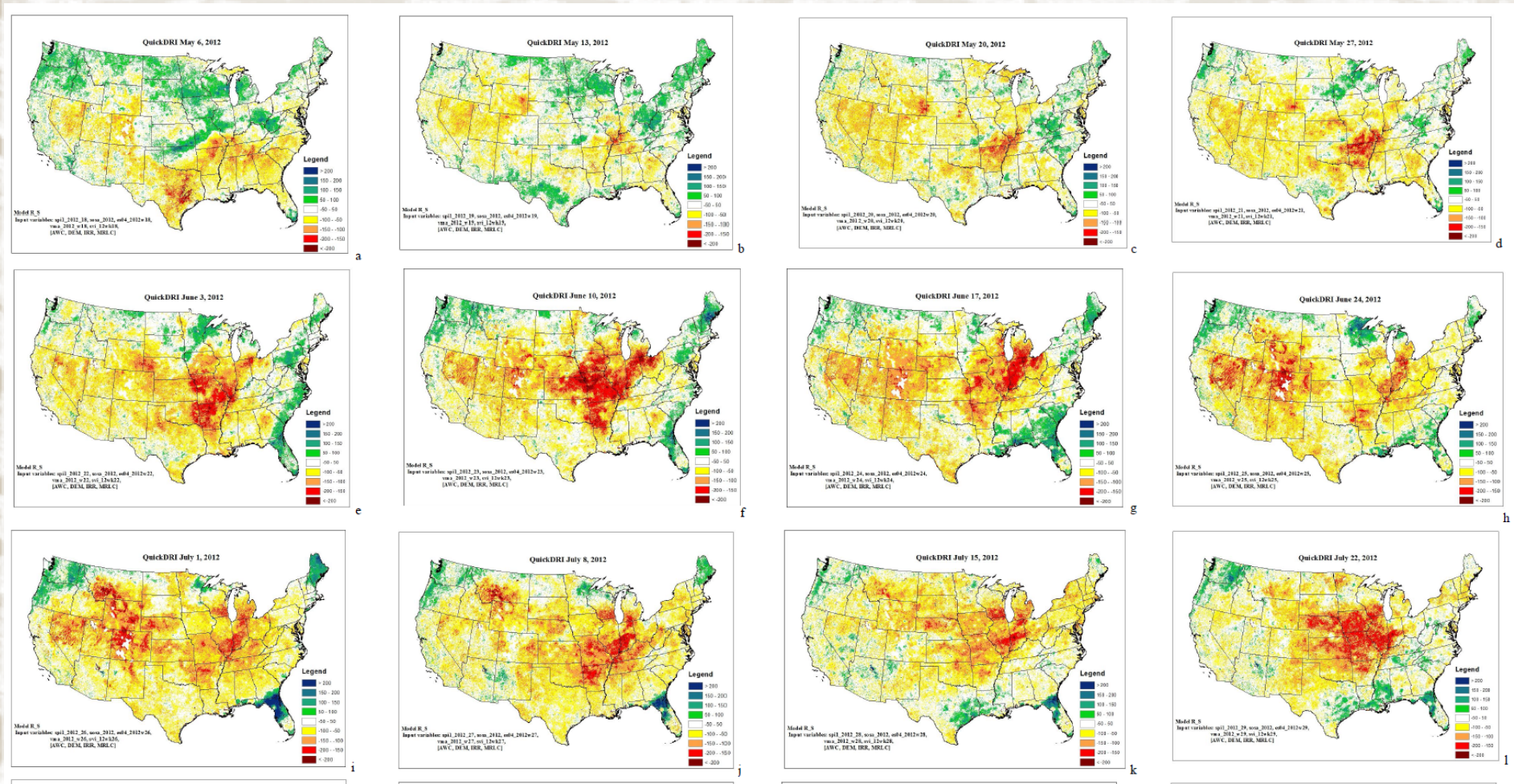
### **Static independent variables:**

- LULC
- Irrigation status
- soil AWC
- elevation
- ecoregion



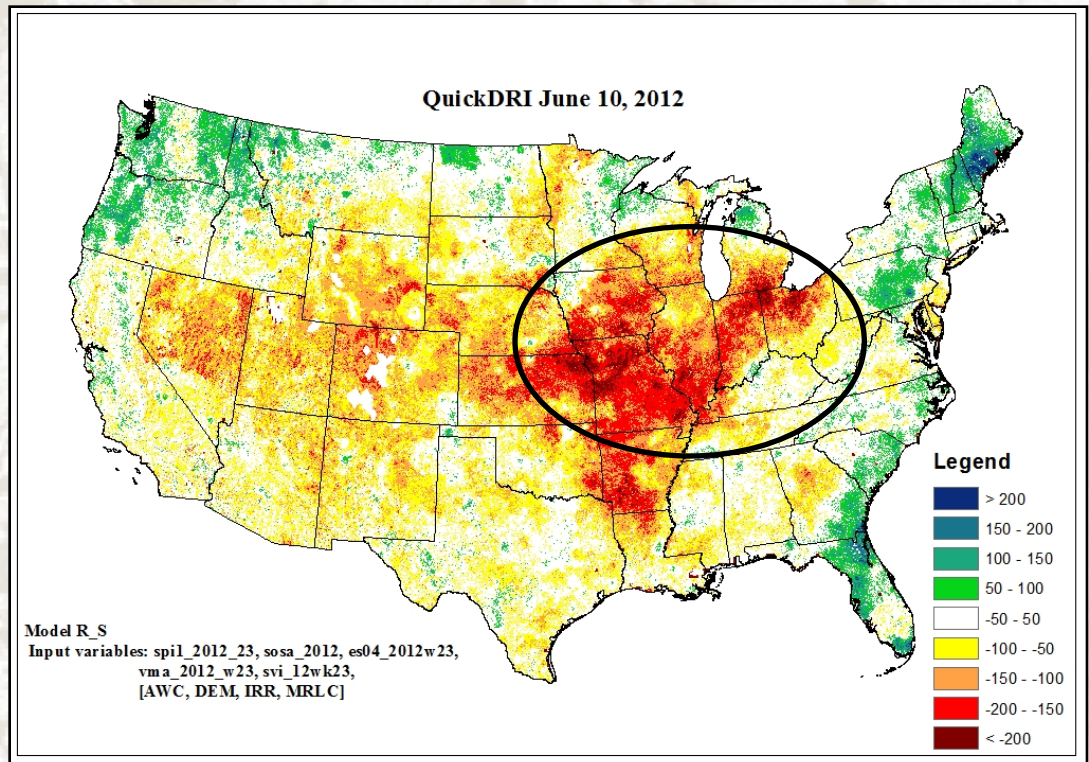
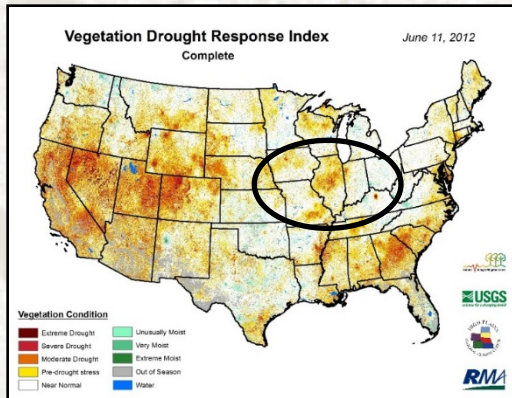
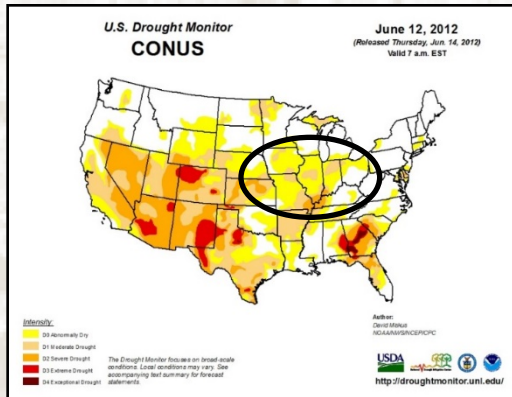
# Milestones – QuickDRI Map Generation Over CONUS

Time series of QuickDRI maps from May through late-July during the 2012 drought in the U.S. Midwest.



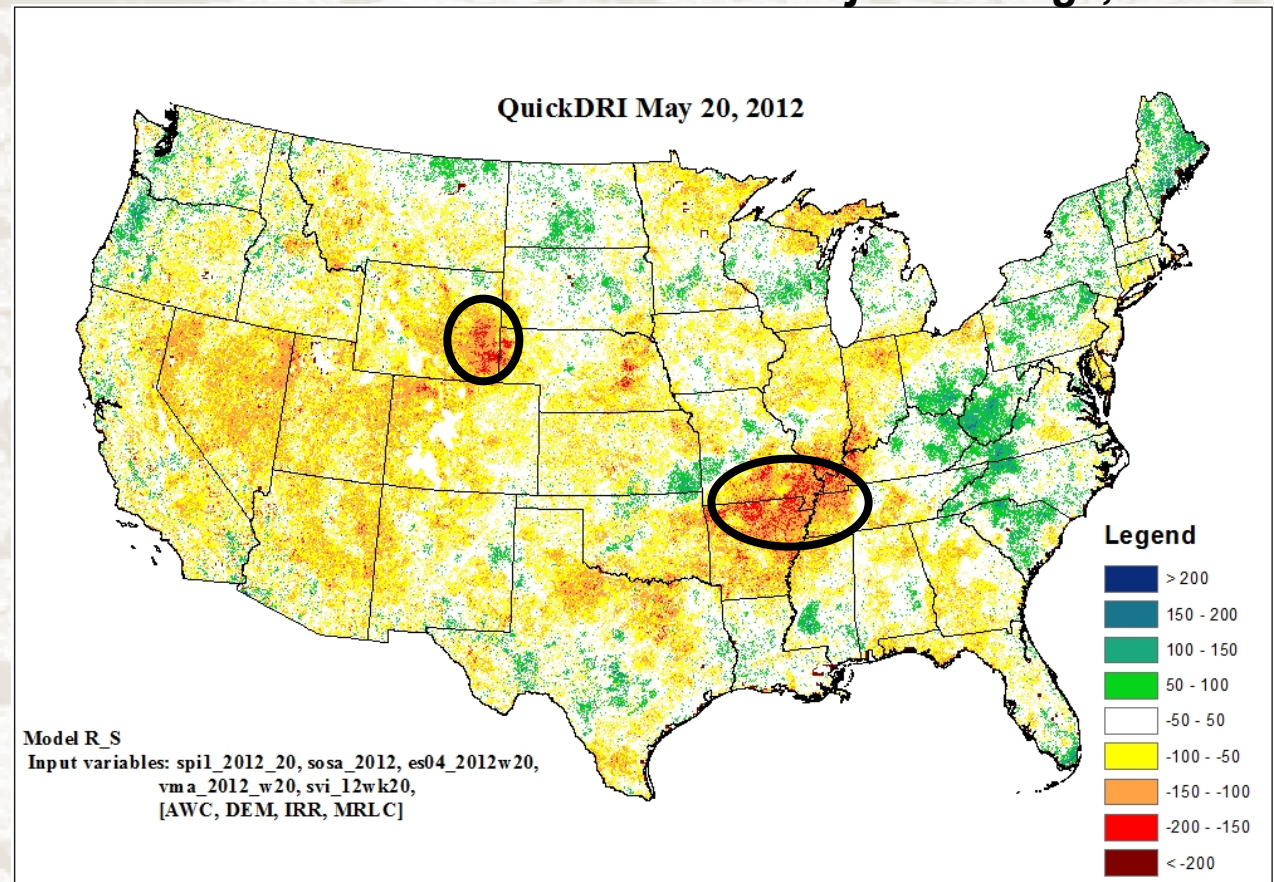
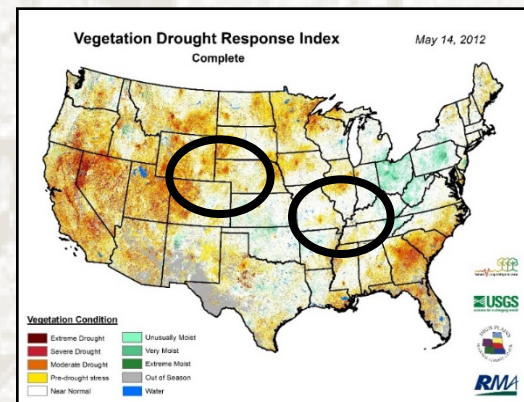
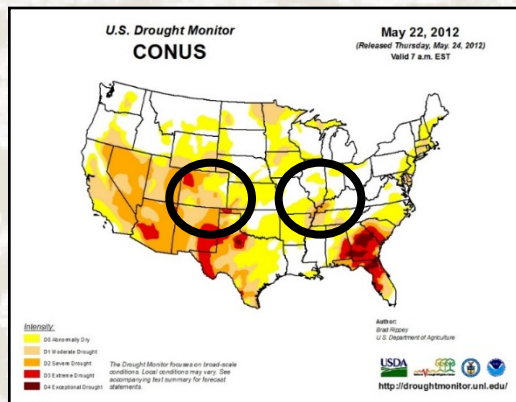
# QuickDRI vs. USDM and VegDRI

Annual time series of QuickDRI maps were completed from 2010 to 2012 for model evaluation during the two major drought events in southern Great Plains (2011) and Midwest (2012).



QuickDRI map for June 10, 2012 shows the widespread, rapid intensification of agricultural drought conditions across much of the U.S. Corn Belt region as shown by the dark and bright reds. In comparison, the USDM map for June 12 and VegDRI map for June 11 show most of the region in pre-drought or non-drought conditions.

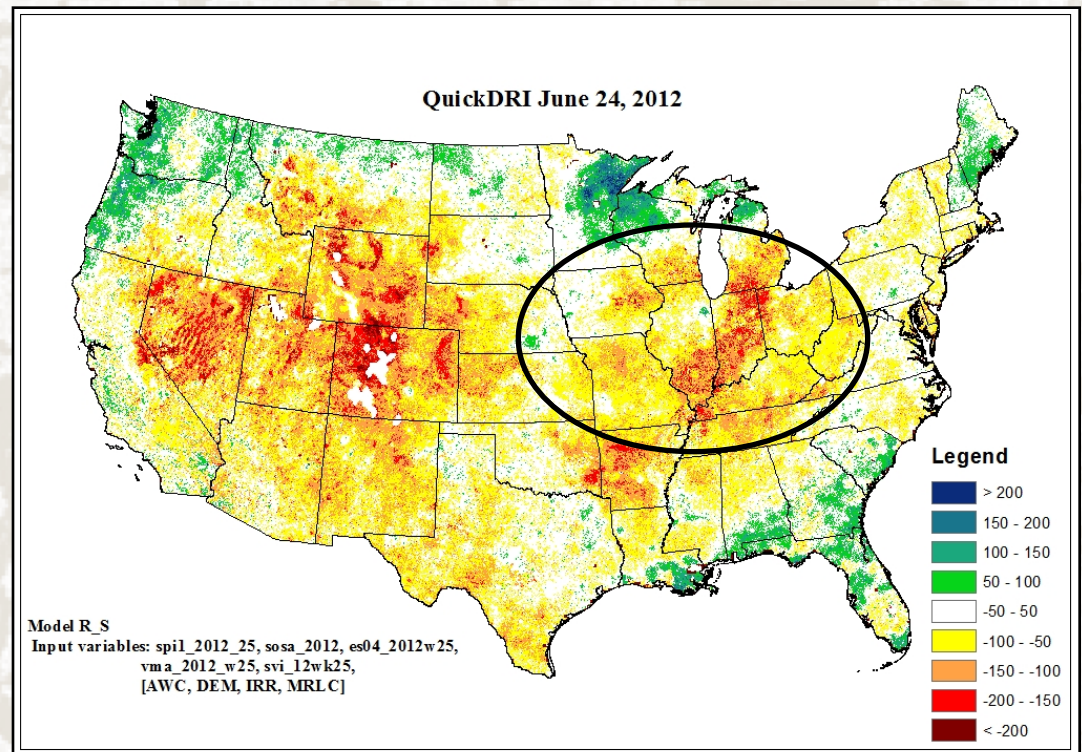
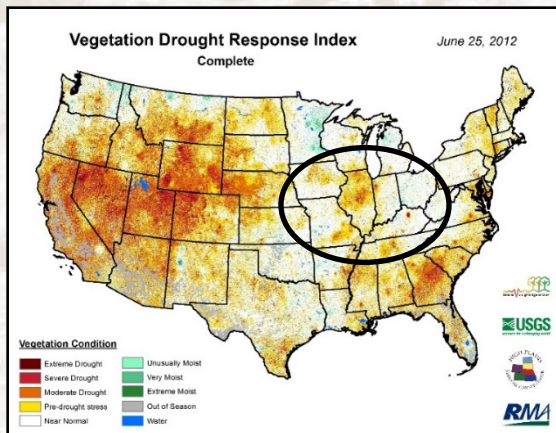
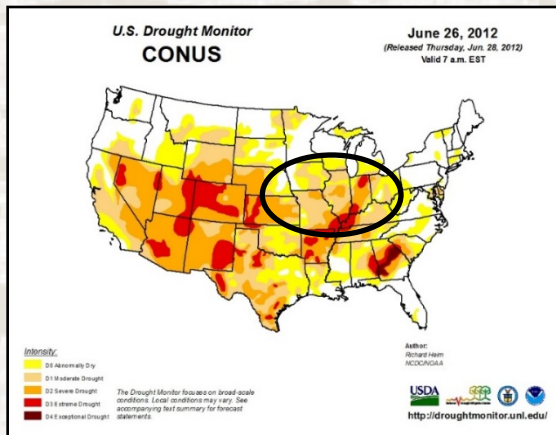
## Major Findings, cont . . .



Some dry patterns omitted or less severe: SE US, wTX/eNM; eWY shown as dry in QuickDRI and VD but not as severe in USDM;  
Severe dry patterns in MO/AR appear to be caught early by QuickDRI (preceding USDM)

# QuickDRI vs. USDM and VegDRI

QuickDRI model results show the index to be an **'alarm' indicator** of rapidly intensifying drought conditions and emerging, rapid-onset drought events ("flash" drought).



**QuickDRI map** shows the **rate of change in drought intensification beginning to slow** as represented by the yellow and orange colors across most of the U.S. Corn Belt. The **USDM map** has **finally introduced the severe to extreme drought conditions that were detected 2 weeks early by QuickDRI**. The **VegDRI map** still **has not introduced these severe drought conditions** because this index is a seasonal indicator (note: drought conditions did appear until early to mid-July across most of the area highlighted by the black oval).

# Current and Future QuickDRI Activities

- **Development and implementation of operational QuickDRI processing system at USGS EROS - *underway***
  - Processing infrastructure and framework completed.
  - Data continuity and quality checks and data specifications of model inputs underway.
  - Testing of system for near real-time (less than 24 hour latency), weekly QuickDRI map production during the 2016 growing season for USDM author evaluation.
  - Final implementation of operational QuickDRI processing system by the Spring 2017.
- **Stakeholder engagement - *planned***
  - Real-time evaluation of QuickDRI maps by USDM authors throughout the 2016 growing season.
  - Listening session(s) with key stakeholders to introduce QuickDRI and solicit feedback for QuickDRI product development. (Fall 2016 – early Spring 2017)
  - Stakeholder workshops to introduce QuickDRI and derivative products and identify key applications beyond the USDM.

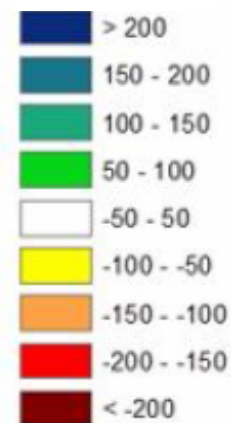
# Current and Future QuickDRI Activities

- **QuickDRI Website and Product Dissemination Mechanisms - *underway***
  - QuickDRI website hosted by the National Drought Mitigation Center (NDMC) to deliver value-added products (e.g., customized maps, areal summaries, narratives) to general public.
  - USGS Drought Viewer hosted by USGS EROS to visualize QuickDRI data within dynamic map viewer and provide access point for download of QuickDRI data (via web services).
- **Benchmarking and assessment of QuickDRI over historical ‘flash’ drought events – *underway***
  - Locations and times of rapidly emerged ‘flash’ drought events identified for recent droughts where most traditional drought indicators lagged in their response.
  - QuickDRI’s performance and sensitivity compared with commonly used drought indicators over benchmark locations.
  - Benefit in the lead time of changing drought conditions characterized and the potential benefit gained by the USDM through this information assessed.

QuickDRI July 1, 2012

# Questions?

Severity



  
National Drought Mitigation Center

**CALMIT**  
University of Nebraska - Lincoln  
Center for Advanced Land Management Information Technologies

  
USGS  
science for a changing world



  
USDA  
dus